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RESEARCH PROGRESS ON

IMAGE SEGMENTATION*

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A survey of recent progress on image segmentation is presented according to statistically based approaches such as the structural methods. Extensive list of literatures on image segmentation is also given.

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1. Introduction

Image segmentation in image processing refers to computer oriented techniques that partition the image into meaningful parts or regions. It is a major function of the low level processing in computer vision. A large amount of research efforts has been devoted to this topic in the past ten years while much more progress is expected in the next decade. Several good survey articles on image segmentation have been published. Fu and Mui [1] reviewed three major approaches to image segmentation, namely, the characteristic feature thresholding, edge detection, and region extraction. The paper also provided 97 references.

So far the image-segmentation techniques are application dependent. A priori information about the type of images is essential to a successful segmentation. For the application in cytology, Ranade and Prewitt [2] compared five segmentation algorithms: two of which are histogram based, another two are quadtree based and the remaining one is the relaxation method. Other references include the surveys by Zucker [3], and Rixeman and Arbib [4], which discussed various techniques, and by Kanade [5] which gave a unified view of the segmentation problem. More complete list of references is in the Appendix.

In this brief report, research progress is reviewed according to the statistically based and the non-statistically based approaches to the segmentation. This dichotomy reflects our view that most segmentation problems can be treated as a statistical problem while many others are more suitably treated by the nonstatistical

methods including the relational methods and the syntactic-structural methods. With this view our emphasis is placed on the application independent and task independent aspects of image segmentation.

2. Statistically-Based Image Segmentation

The most familiar statistical image segmentation procedure is by thresholding the gray scale picture. The optimal thresholds can be determined or approximated statistically. The thresholding methods followed by other post-processing procedures such as gap filling, etc. are the most practical approach to image segmentation. The next statistical segmentation approach is via spatial clustering which is considered as an unsupervised pattern classification. Image segmentation can be performed with pixel classification [6-9]. The supervised segmentation generally performs better than the unsupervised segmentation. For the images with additive noise, statistical boundary estimation [10] can provide region extraction. Segmentation can also be considered as an estimation problem [11] in which regions are grown with the aid of estimated parameters. Furthermore, the homogeneity and common characteristics of a region can be tested statistically with, e.g., F-statistic, K-S test, etc.

Although contextral analysis in statistical pattern recogniton [12] is difficult, simple statistical-spatial models can be very effective in segmentation. The fundamental limitation of the statistical approaches is that the image information content is not entirely statistical except for the purely random noise image.

Even for the textured images for which the statistical models are effective, structural information can be very important. It is necessary to develop a structural model in some images and estimate its parameters with the aid of the statistical methods.

3. Relational Approach to Image Segmentation

In this approach, the nonstatistical relationships are established between segments or regions. The segments can be as small as pixels. The best example of the relational approach is the quadtree structure proposed by Rosenfeld [13]. The region/edge coordination is performed locally so that the noise points which may be present elsewhere in the image have no effect on this coordination. The coordination process is important to the relational approach in general. Semantic information can also be utilized in the relational approach. The relaxation method in image segmentation needs good initial conditions. The region information obtained from analysis of the histogram of the original image can be used to initialize the class membership indices. Such indices can be probabilistic relations to be estimated recursively.

4. Structural-Syntactic Approach

The basic units of structure in images are primitives. Grammatical rules can be established such that the image can be described by a language. This formal approach in structural analysis is called the syntactic approach. In general, any method which exploits the structure of the images is a structural approach.

Detection of curves, lines, etc. is a structural approach that can accomplish image segmentation. In other images such as the acoustic ambuguity function, the inherent functional relation is a structure which is useful in extracting the region of interests. Thus the scope of the structural approach is very broad. Obviously the statistical and the structural approaches should be combined as much as possible to utilize fully the complex informational content of an image so that segmentation can be performed effectively. Major progress on the structural-syntactic approach to image segmentation has been reported recently at the Saratoga Springs Workshop [14]. The fundamental problem is the primitive selection which does not appear to have a formal solution. A feedback link has been suggested that allows the re-selection of primitives after making the decision based on the original primitives. Another interesting procedure suggests the joint use of the local and the global procedures. These directions remain to be explored.

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